Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **May/June 2018**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **one** question.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Section A

Answer **all** questions.

1 The Sumatran orangutan, *Pongo abelii*, is found only on the island of Sumatra, Indonesia.

Fig. 1.1 shows a Sumatran orangutan.

Fig. 1.1

(a) The International Union for Conservation of Nature (IUCN) is the world's largest global environmental organisation. The IUCN Red List of Threatened Species™ evaluates the conservation status of plant and animal species. The Sumatran orangutan is categorised as critically endangered on the IUCN Red List.

The Sumatran orangutan spends most of its time in trees and is very sensitive to habitat destruction.

Table 1.1 shows the area of natural forest of Sumatra and the numbers of orangutans in 1985 and 2016.

Table 1.1

	1985	**2016**
area of natural forest / million hectares	25.3	12.4
number of orangutans	25 000	7300

(i) With reference to Table 1.1, state the relationship between area of natural forest and number of orangutans.

.....

.....[1]

(ii) Calculate the mean annual decrease in orangutan numbers between 1985 and 2016.

Show your working.

Give your answer to the nearest whole number.

mean annual decrease = ...[2]

(iii) Use your answer from **(a)(ii)** to estimate the number of years after 2016 that it will take for the Sumatran orangutan to become extinct in the wild, if conservation work is unsuccessful.

..... years [1]

(b) Suggest **two** reasons for the decrease in numbers of Sumatran orangutans, other than habitat loss.

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.....[2]

(c) Outline the role zoos can take in the protection of the Sumatran orangutan.

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.....[3]

[Total: 9]

2 Scientists have found very little evolutionary change in populations of two Australian songbirds, the zebra finch, *Taeniopygia guttata castanotis*, and the budgerigar, *Melopsittacus undulatus*.

(a) Describe the process of evolution by natural selection.

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.....[4]

(b) The number of eggs a bird lays in its nest is called the clutch size.

The variation in clutch size was investigated in the zebra finch over several years.

The data are shown in Fig. 2.1.

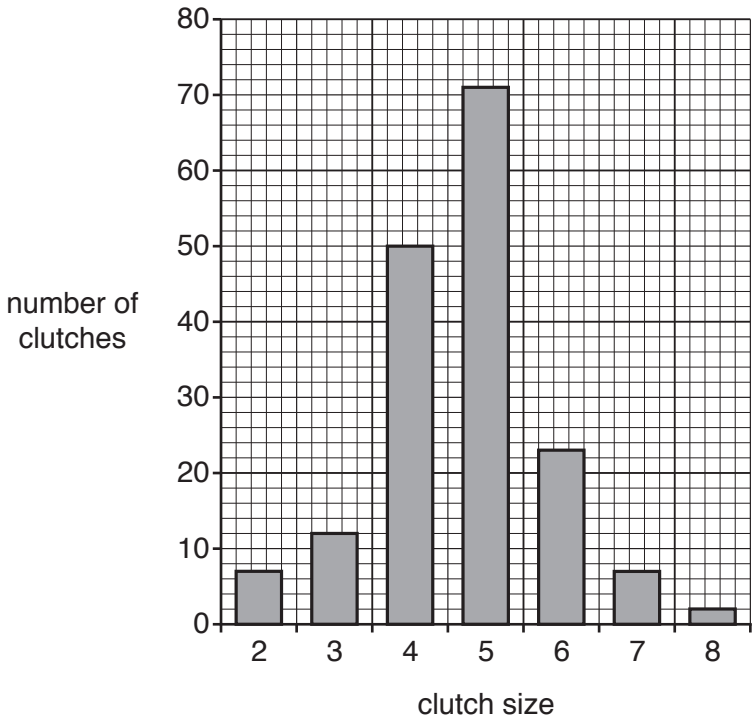

Fig. 2.1

(i) Describe the pattern shown by the data in Fig. 2.1.

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.....[2]

(ii) The data in this investigation were collected over 60 years ago.

The same investigation, carried out today, would produce the same pattern of results.

Explain how the selection factors acting on zebra finches would maintain the same pattern of results.

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.....[4]

(c) The Hardy–Weinberg principle is used to calculate allele, genotype and phenotype frequencies in populations.

- A breeder of birds keeps a population of 86 budgerigars in one enclosed area.
- Two distinct phenotypes are present, blue feathers and green feathers.
- Feather colour is controlled by one gene:
  - **G** is the allele for green feathers
  - **g** is the allele for blue feathers.
- Only 17 of the budgerigars have blue feathers.

(i) The Hardy–Weinberg equations are shown in Fig. 2.2.

$$p + q = 1$$

$$p^2 + 2pq + q^2 = 1$$

Fig. 2.2

Calculate the number of heterozygous individuals in the population.

Show your working.

number = ...[3]

(ii) The Hardy–Weinberg principle cannot be applied to all populations.

State **two** conditions when the Hardy–Weinberg principle **cannot** be applied.

1 .....

.....

2 .....

.....[2]

[Total: 15]

3 **(a)** The *lac* operon is a section of DNA present in the genome of the bacterium *Escherichia coli*. The structural genes of the operon are only fully expressed when *E. coli* is exposed to high lactose concentrations.

(i) Fig. 3.1 is a diagram showing the *lac* operon and a nearby region of the *E. coli* genome.

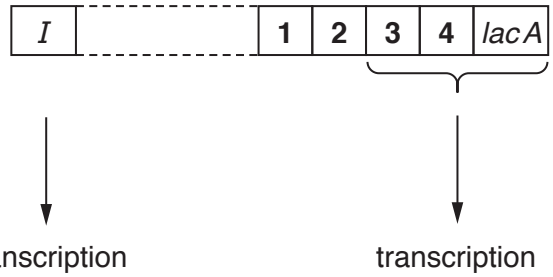

Fig. 3.1

Name sections **1**, **2**, **3** and **4** shown in Fig. 3.1.

1 .....

2 .....

3 .....

4 .....

[2]

(ii) Certain enzymes need to be present inside *E. coli* for it to be able to take up and use lactose. When the genes of the *lac* operon are expressed, the enzymes β-galactosidase and lactose permease are produced in large quantities.

Outline the functions of β-galactosidase and lactose permease.

β-galactosidase .....

.....

.....

lactose permease .....

.....

.....

[2]

(b) (i) Gene *I* is located a short distance away from the *lac* operon.

The product of gene *I*, a repressor protein, is a constitutive protein.

State what is meant by the term *constitutive protein*.

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.....[1]

(ii) Explain why the structural genes of the *lac* operon are **not** expressed when lactose is absent.

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.....[3]

(iii) A strain of *E. coli* has been produced with a mutation in gene *I*. Expression of this gene results in a non-functional repressor protein.

Suggest a negative effect that this mutation will have on this strain of *E. coli*.

.....

.....[1]

[Total: 9]

4 Domestic goats, *Capra hircus*, show a wide range of coat patterns and colours. One gene involved in coat colour and pattern has multiple alleles. Four of these alleles are:

- **A**, the allele for white, is dominant to all others
- $\mathbf{A^b}$, the allele for badgerface (stripes on face) and $\mathbf{A^g}$, the allele for grey, are codominant
- **a**, the allele for black, is recessive to all others.

(a) State **all** the possible genotypes of:

a grey badgerface goat .....

a white goat. .....

[2]

(b) A cross between a black goat and a white goat produced a white goat. This white offspring was crossed with a grey goat. The genotype of the grey goat was not known.

Use genetic diagrams to show **all** the possible offspring genotypes and phenotypes that could result from the cross between the white offspring and the grey goat.

[4]

(c) When goat skin cells produce black melanin pigment these events occur:

- Melanocyte stimulating hormone (MSH) is secreted into the bloodstream.
- MSH binds to the melanocortin 1 receptor on the cell surface membranes of skin cells.
- This causes a rise in cyclic AMP within the cell.
- The enzyme tyrosinase is activated and begins melanin production.

The white allele **A** codes for a protein that binds irreversibly to the melanocortin 1 receptor. No rise in cyclic AMP occurs, even when MSH is present in the blood.

Explain the appearance of goats with genotype **aa**.

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.....[2]

[Total: 8]

5 **(a)** Pigs are farm animals used for livestock in some parts of the world. The first genetically modified (transgenic) pigs were produced in 1985. Foreign DNA was injected directly into the nuclei of zygotes. The foreign DNA was made up of two components:

- the gene coding for human growth hormone
- a section of mouse DNA that, in the presence of metal ions, allows transcription to begin.

(i) The human growth hormone synthesised by the transgenic pigs had the effect of making the pigs grow faster, larger and heavier than non-genetically modified pigs.

Suggest reasons for this difference.

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.....[2]

(ii) Suggest **and** explain why the mouse DNA was included in the foreign DNA.

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.....[3]

[Turn over

Only 1% of the attempts successfully produced transgenic pigs. These pigs showed higher body mass and a greater muscle to fat ratio than normal pigs. Monitoring of the pigs' behaviour revealed that they rested more than normal pigs, suffered from stomach ulcers and were unwilling to mate.

(b) (i) Discuss whether these transgenic pigs have long term economic value.

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.....[3]

(ii) Comment on the ethics of producing transgenic pigs showing the features described.

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.....[2]

(c) In 2015 pigs were produced that had part of their genome altered by a new technique. The technique involved:

- an RNA sequence designed to bind to a specific targeted pig gene
- a gene-editing enzyme that is able to cut out sections of DNA.

The technique was used on pig zygotes that had been created by IVF. All the zygotes treated grew into piglets and these all showed large deletions in the targeted gene.

This gene coded for a specific cell surface membrane protein. The piglets did not express the protein and this gave them resistance to infection by a virus that causes a serious disease in pigs.

(i) Describe **two** advantages of the gene-editing technique compared to the traditional genetic modification technique used to make transgenic pigs in 1985.

.....

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.....[2]

(ii) A scientist stated that this new technique is a form of selective breeding, so is not genetic engineering.

Discuss whether this statement is true **and** whether public groups who oppose transgenic animals will be more or less likely to accept the new technique.

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.....[3]

[Total: 15]

[Turn over

6 **(a)** Fig. 6.1 shows a transmission electron micrograph of a section through a mitochondrion.

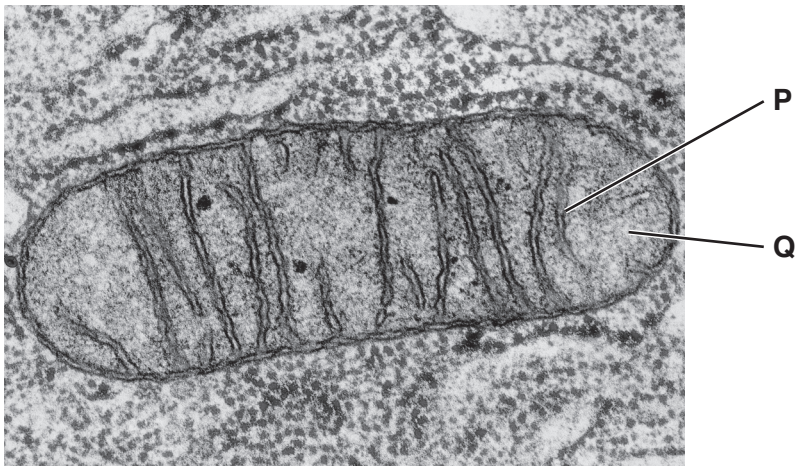

Fig. 6.1

Table 6.1 shows some structures and compounds involved in aerobic respiration.

Use letter **P** or letter **Q** from Fig. 6.1 to complete Table 6.1 to show the location of the structures and where the compounds are used.

Table 6.1

compound or structure	location
ATP synthase	.....
acetyl CoA	.....
phospholipid bilayer	.....
oxaloacetate	.....

[3]

(b) The number of mitochondria differs from cell to cell. Cells also vary in size and volume.

Table 6.2 shows the mean number of mitochondria per cell, the mean cell volume and the mean number of mitochondria per μm^3 of three types of mammalian cells.

Table 6.2

cell type	mean number of mitochondria per cell	mean cell volume / μm^3	mean number of mitochondria per μm^3
fat cell	100	600 000	0.17×10^{-3}
heart cell	2000	45 000	44.44×10^{-3}
liver cell	2000	125 000	.....

(i) Calculate the mean number of mitochondria per μm^3 for the liver cell.

Write your answer in Table 6.2. [1]

(ii) Suggest reasons for the difference in mean number of mitochondria per μm^3 between the fat cell and the heart cell.

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.....[2]

(iii) Suggest why it is difficult to compare the ability of the three types of cell to respire aerobically, based **only** on the mean number of mitochondria per cell.

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.....[1]

[Total: 7]

7 **(a)** Fig. 7.1 outlines the process of non-cyclic photophosphorylation in the chloroplast of a leaf mesophyll cell.

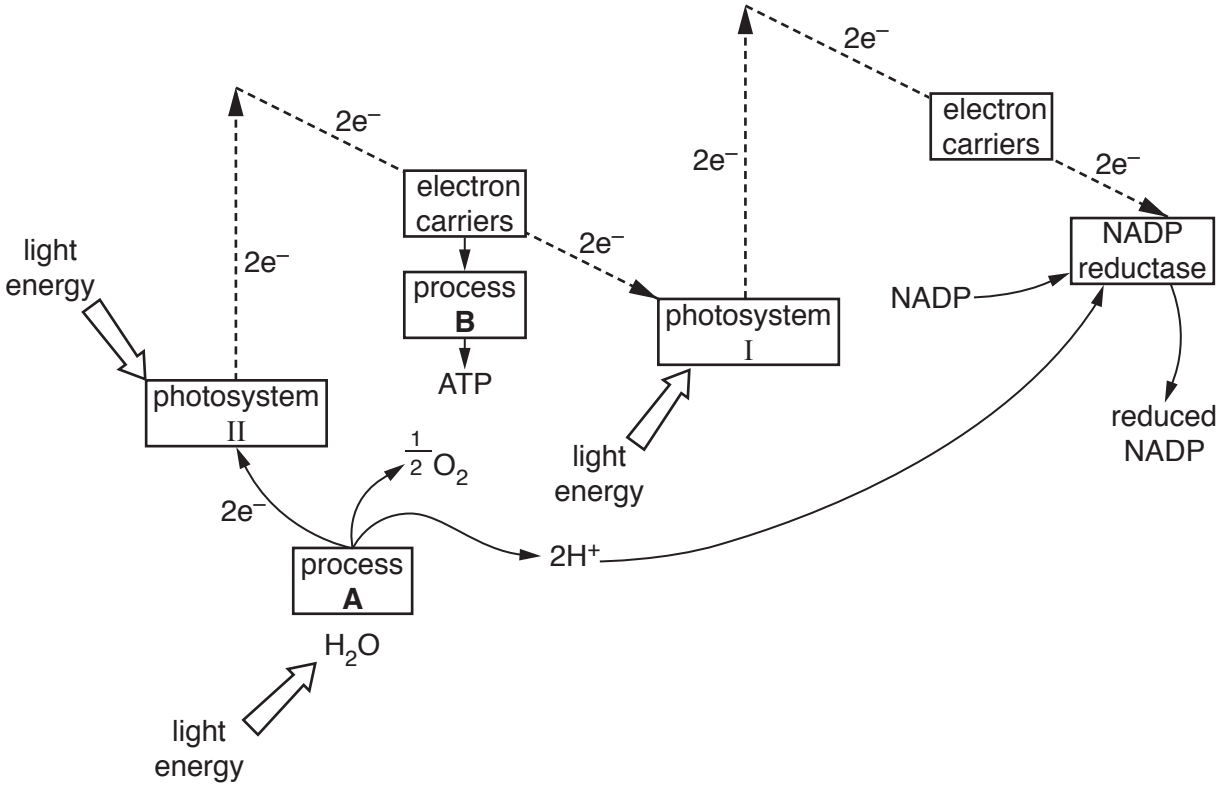

Fig. 7.1

(i) State precisely where non-cyclic photophosphorylation occurs in the chloroplast.

.....[1]

(ii) With reference to Fig. 7.1, name processes **A** and **B**.

A .....

B .....[2]

(iii) State what happens to the oxygen produced by process **A**.

.....

.....[1]

(iv) Name the primary pigment in photosystem I and photosystem II.

.....[1]

(v) Name **two** compounds shown in Fig. 7.1 that are used in the conversion of glycerate-3-phosphate (GP) to triose phosphate (TP) in the Calvin cycle.

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.....[1]

(b) Outline the uses of triose phosphate in the mesophyll cells of the leaf.

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.....[3]

[Total: 9]

8 **(a)** In mammals, the nervous system and the endocrine system coordinate responses to the changes in internal and external environments.

Complete Table 8.1 to indicate the differences between the nervous system and the endocrine system.

Table 8.1

feature	nervous system	endocrine system
method of communication	.....	.....
method of transmission	.....	.....
transmission speed	.....	.....
duration of effect	.....	.....

[4]

(b) Fig. 8.1 shows the changes in the concentration of hormones in the blood during the menstrual cycle.

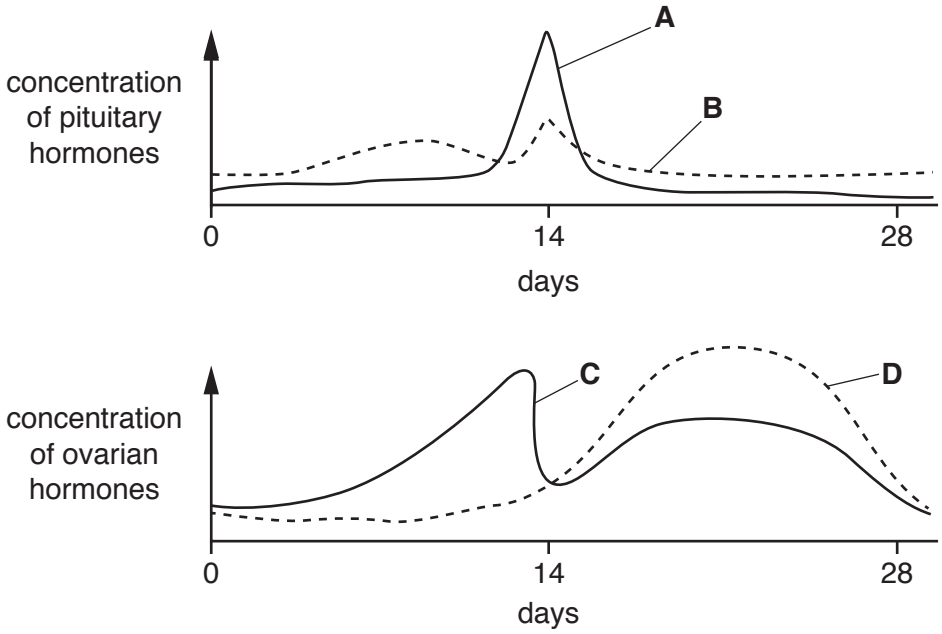

Fig. 8.1

With reference to Fig. 8.1, match hormones **A**, **B**, **C** or **D** to the correct statements 1 to 4.

Each hormone may be used once, more than once or not at all.

1 made by the corpus luteum .....

2 stimulates the repair of the endometrium .....

3 maintains the endometrium .....

4 stimulates ovulation .....

[4]

(c) Outline the biological basis for contraceptive pills containing oestrogen and progesterone.

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.....[5]

[Total: 13]

Section B

Answer **one** question.

9 **(a)** Describe the features of ATP that make it suitable as the universal energy currency. [6]

(b) Outline respiration in anaerobic conditions in mammalian cells **and** describe how it differs from respiration in anaerobic conditions in yeast cells. [9]

[Total: 15]

10 **(a)** Describe the structure of a sensory neurone. [6]

(b) Describe how a resting potential is set up **and** maintained in a myelinated neurone. [9]

[Total: 15]

[Turn over

[Turn over